1. PUBLIC HEALTH STATEMENT

This public health statement tells you about nickel and its compounds and the effects of exposure.

The Environmental Protection Agency (EPA) identifies the most serious hazardous waste sites in the nation. These sites make up the National Priorities List (NPL) and are targeted for long-term federal clean-up activities. Nickel has been found in at least 709 of the 1,430 current or former NPL sites. However, the total number of NPL sites evaluated is not known. As more sites are evaluated, the number of sites at which nickel is found may increase. This is important because exposure to this substance, may harm you and because these sites may be sources of exposure.

When a substance is released from a large area, such as an industrial plant, or from a container, such as a drum or bottle, it enters the environment. This release does not always lead to exposure. You are exposed to a substance only when you come in contact with it by breathing, eating, touching, or drinking.

If you are exposed to nickel, many factors will determine whether you'll be harmed. These factors include the dose (how much), the duration (how long), and how you come in contact with it. You must also consider the other chemicals you're exposed to and your age, sex, diet, family traits, lifestyle, and state of health.

1.1 WHAT IS NICKEL?

Pure nickel is a hard, silvery-white metal, which has properties that make it very desirable for combining with other metals to form mixtures called alloys, Some of the metals that nickel can be alloyed with are iron, copper, chromium, and zinc. These alloys are used in making metal coins and jewelry and in industry for making items such as valves and heat exchangers. Most nickel is used to make stainless steel. Compounds of nickel combined

with many other elements, including chlorine, sulfur, and oxygen, exist. Many of these compounds dissolve fairly easily in water and have a characteristic green color. Nickel and its compounds have no characteristic odor or taste. Nickel compounds are used for nickel plating, to color ceramics, to make some batteries, and as substances known as catalysts that increase the rate of chemical reactions.

Nickel combined with other elements occurs naturally in the earth's crust. It is found in all soil, and is also emitted from volcanos. Nickel is the 24th most abundant element. In the environment it is found primarily combined with oxygen or sulfur as oxides or sulfides. Nickel is also found in meteorites and on the ocean floor in lumps of minerals known as sea floor nodules. The earth's core contains large amounts of nickel. Nickel is released into the atmosphere during nickel mining and by industries that make alloys or nickel compounds or industries that use nickel and its compounds. These industries may also discharge nickel in waste water. Nickel is also released into the atmosphere by oil-burning power plants, coal-burning power plants, and trash incinerators.

There is only one nickel mine in operation in the United States. The mine is located in Riddle, Oregon. Most of our new nickel is imported from Canada. Much of our domestic nickel comes from recycling nickel-containing alloys.

See Chapters 3 and 4 of this profile for more information on the properties, sources, and uses of nickel and its compounds.

1.2 WHAT HAPPENS TO NICKEL WHEN IT ENTERS THE ENVIRONMENT?

Nickel may be released to the environment from the stacks of large furnaces used to make alloys or from power plants and trash incinerators. The nickel that comes out of the stacks of power plants is attached to small particles of dust that settle to the ground or are taken out of the air in rain. It usually takes many days for nickel to be removed from the air. If the nickel is attached to very small particles, removal can take longer than a

month. Nickel can also be released in waste water. A lot of nickel released into the environment ends up in the soil or sediment where it is strongly attached to particles containing iron or manganese. Under acidic conditions, nickel is more mobile in soil and may seep into groundwater. Nickel does not appear to concentrate in fish. Studies show that it does not accumulate in plants growing on land that has been treated with nickelcontaining sludge or in small animals living on that land.

See Chapter 5 for more information on the fate of nickel in the environment.

1.3 HOW MIGHT I BE EXPOSED TO NICKEL?

Nickel normally occurs at very low levels in the environment, and therefore, very sensitive methods are needed to detect nickel in most environmental samples. You may be exposed to nickel by breathing air, drinking water, eating food, or smoking tobacco containing nickel. Skin contact with soil, water, or metals containing nickel as well as with metals plated with nickel can also result in exposure. Stainless steel and coins contain nickel. Jewelry is often plated with nickel or made from nickel alloys. Patients may be exposed to nickel in artificial body parts made from nickel-containing alloys.

We often do not know the form of nickel to which we are exposed. Much of the nickel found in sediment, soil, and rock is so strongly attached to dust and soil particles or embedded in minerals that it is not readily taken up by plants and animals and cannot easily affect your health. We do not know what forms of nickel are found at most hazardous waste sites.

Nickel in air is attached to small particles. Over a 6-year period (1977-1982) in the United States, average nickel concentrations in cities and in the country ranged from 7 to 12 nanograms per cubic meter (ng/m^3; 1 ng/m^3 is equivalent to 1 billionth of a gram in a cubic meter of air).

1. PUBLIC HEALTH STATEMENT

The concentration of nickel in water from rivers and lakes is very low. The average concentration of nickel is usually less than 10 parts of nickel in a billion parts of water (ppb) in rivers and lakes. The level of nickel in water is often so low that we cannot measure it unless we use very sensitive instruments. The average concentration of nickel in drinking water is about 2 ppb. However, you may be exposed to higher than average levels of nickel in drinking water if you live near industries that process or use nickel. The highest levels of nickel in drinking water, about 72 ppb, have been found in Sudbury Ontario, Canada, where there is a large natural nickel deposit and where nickel is mined and refined.

Soil usually contains between 4 and 80 parts of nickel in a million parts of soil (ppm; 1 ppm is 1,000 times greater than 1 ppb). The highest soil concentrations (up to 9,000 ppm) are found near industries where nickel is extracted from ore. High concentrations of nickel occur because dust released to air from stacks during processing settles on the ground. You may be exposed to nickel in soil by skin contact. Children may also be exposed to nickel by eating soil.

Food contains nickel and is the major source of nickel exposure for the general population. You eat about 170 micrograms (μg; 1 μg = 1,000 ng) of nickel in your food every day. Foods naturally high in nickel include chocolate, soy beans, nuts, and oatmeal. Our daily intake of nickel from drinking water is only about 2 μg. We breathe in between 0.1 and 1 μg nickel/day, excluding nickel in tobacco smoke. We are exposed to nickel when we handle coins and touch other metals containing nickel.

You may be exposed to higher levels of nickel if you work in industries that process or use nickel. You may be exposed to nickel by breathing dust or fumes (as from welding) or by skin contact with nickel-containing metal and dust or solutions containing dissolved nickel compounds. A national survey conducted from 1980 to 1983 estimated that 727,240 workers are potentially exposed to nickel metal, nickel alloys, or nickel compounds.

1. PUBLIC HEALTH STATEMENT

For more information on the potential for exposure to nickel, please see Chapter 5.

1.4 HOW CAN NICKEL ENTER AND LEAVE MY BODY?

Nickel can enter your body when you breathe air containing nickel, when you drink water or eat food that contains nickel, and when your skin is in contact with nickel. If you breathe air that contains nickel dust, the amount of inhaled nickel that reaches your lungs and enters your blood depends on the size of the dust particles. If the particles are large, they stay in your nose. If the particles are small, they can enter deep into your lungs. More nickel is absorbed from your lungs into your body when the dust particles can dissolve easily in water. When the particles do not dissolve easily in water, the nickel may remain in your lungs for a long time. Some of these nickel particles can leave the lungs with mucus that you spit out or swallow. More nickel will pass into your body through your stomach and intestines if you drink water containing nickel than if you eat food containing the same amount of nickel. A small amount of nickel can enter your bloodstream after being placed on your skin. After nickel gets into your body, it can go to all organs, but it mainly goes to the kidneys. The nickel that gets into your bloodstream leaves in the urine. After nickel is eaten, most of it leaves quickly in the feces, and the small amount that gets into your blood leaves in the urine. For more information on how nickel can enter and leave your body, see Chapter 2.

1.5 HOW CAN NICKEL AFFECT MY HEALTH?

Nickel is essential to maintaining good health in animals. A small amount of nickel is probably essential for humans also, although nickel levels in humans have not been lowered enough to affect the health of humans.

The most common adverse health effect of nickel in humans is an allergic reaction to nickel. People can become sensitive to nickel when jewelry or other things containing nickel are in direct contact with the skin. Wearing earrings containing nickel in pierced

1. PUBLIC HEALTH STATEMENT

ears may also sensitize people to nickel. Once a person is sensitized to nickel, further contact with the metal will produce a reaction. The most common reaction is a skin rash at the site of contact. In some sensitized people dermatitis may develop at a site away from the site of contact. For example, hand eczema is fairly common among people sensitized to nickel. Less frequently, some people who are sensitive to nickel have asthma attacks following exposure to nickel. People who are sensitive to nickel have reactions when nickel is in contact with the skin. Some sensitized individuals react when they eat nickel in food or water, or breathe dust containing nickel. More women are sensitive to nickel than men. This difference between men and women is thought to be a result of greater exposure of women to nickel through jewelry and other metal items.

People who are not sensitive to nickel must eat very large amounts of nickel to suffer adverse health effects. Workers who accidentally drank light-green water containing 250 ppm nickel from a contaminated drinking fountain had stomach aches and suffered adverse effects in their blood (increased red blood cells) and kidneys (increased protein in the urine). This concentration of nickel is more than 100,000 times greater than the amount of nickel usually found in drinking water. A 2-year-old child died from heart failure after eating 5,700 milligrams (mg; 1 milligram = 1 one-thousandth of a gram, or 1,000 µg) of nickel as crystals of nickel sulfate. The dose of nickel that this child ate was about 50,000 times greater than the usual daily intake of a child. Levels of nickel in the environment or at hazardous waste sites will not result in deaths of humans.

The most serious effects of nickel, such as cancer of the lung and nasal sinus, have occurred in people who have breathed dust containing nickel compounds while working in nickel refineries or in nickel processing plants. The levels of nickel in the workplace were much higher than background levels. Lung and nasal sinus cancers occurred when the workers were exposed to more than 10 mg nickel/m^3 as nickel compounds that were hard to dissolve (such as nickel subsulfide). Exposure to high levels of nickel compounds that dissolve easily in water may also result in cancer when nickel compounds that are hard to dissolve are present, or when other chemicals that can cause cancer are present. The

1. PUBLIC HEALTH STATEMENT

concentrations of soluble and less-soluble nickel compounds that were found to have caused cancers were 100,000 to 1 million times greater than the usual level of nickel in the air in the United States. The U.S. Department of Health and Human Services (DHHS) has determined that nickel and certain nickel compounds may reasonably be anticipated to be carcinogens. The International Agency for Research on Cancer (IARC) has determined that some nickel compounds are carcinogenic to humans and that metallic nickel may possibly be carcinogenic to humans. The EPA has determined that nickel refinery dust and nickel subsulfide are human carcinogens.

Other lung effects including chronic bronchitis and reduced lung function have been observed in workers breathing nickel. Current levels of nickel in workplace air are much lower than in the past, and few workers have symptoms from nickel exposure.

To protect the public from the harmful effects of toxic chemicals and to find ways to treat people who have been harmed, scientists use many tests.

One way to see if a chemical will hurt people is to learn how the chemical is absorbed, used, and released by the body; for some chemicals, animal testing may be necessary. Animal testing may also be used to identify health effects such as cancer or birth defects. Without laboratory animals, scientists would lose a basic method to get information needed to make wise decisions to protect public health. Scientists have the responsibility to treat research animals with care and compassion. Laws today protect the welfare of research animals, and scientists must comply with new strict animal care guidelines.

Breathing high levels of nickel compounds can result in effects on the lungs and the rest of the respiratory tract. Animal studies show that, in short-term exposures, breathing high levels of nickel compounds that dissolve easily in water may result in inflammation of the respiratory tract. Long-term exposure to lower levels of a nickel compound that dissolves easily in water did not cause cancer in animals. These studies have also shown that some of the nickel compounds that do not dissolve in water can have serious respiratory effects

if breathed for a long time (for example, in nickel smelting plants where workers are unprotected). Lung cancer developed in rats exposed for a long time to nickel compounds that do not dissolve easily in water.

Oral exposure of humans to high levels of soluble nickel compounds through the environment is extremely unlikely. Therefore, since humans have only rarely been exposed to high levels of nickel in water or food, much of our knowledge of nickel toxicity is based on animal studies. Eating or drinking levels of nickel very much greater than the levels normally found in food and water have been reported to cause lung disease in dogs and rats and to affect the stomach, blood, liver, kidneys, immune system, and reproduction and development in rats and mice.

See Chapter 2 for more information on the health effects of nickel exposure.

1.6 IS THERE A MEDICAL TEST TO DETERMINE WHETHER I HAVE BEEN EXPOSED TO NICKEL?

Measurements of the amount of nickel in your blood, feces, and urine can be used to estimate your exposure to nickel. More nickel was found in the urine of workers who were exposed to nickel compounds that dissolve easily in water (soluble) than in the urine of workers exposed to compounds that are hard to dissolve (less-soluble). This means that it is easier to tell if you have been exposed to soluble compounds than less-soluble compounds. The nickel measurements do not accurately predict potential health effects from exposure to nickel. More information on medical tests can be found in Chapters 2 and 6.

1.7 WHAT RECOMMENDATIONS HAS THE FEDERAL GOVERNMENT MADE TO PROTECT HUMAN HEALTH?

The federal government develops regulations and recommendations to protect public health. Regulations can be enforced by law. Federal agencies that develop regulations for toxic substances include the Environmental Protection Agency (EPA), the Occupational Safety

and Health Administration (OSHA), and the Food and Drug Administration (FDA). Recommendations provide valuable guidelines to protect public health but cannot be enforced by law. Federal organizations that develop recommendations for toxic substances include the Agency for Toxic Substances and Disease Registry (ATSDR) and the National Institute for Occupational Safety and Health (NIOSH).

Regulations and recommendations can be expressed in not-to-exceed levels in air, water, soil, or food that are usually based on levels that affect animals, then they are adjusted to help protect people. Sometimes these not-to-exceed levels differ among federal organizations because of different exposure times (an 8-hour workday or a 24-hour day), the use of different animal studies, or other factors.

Recommendations and regulations are also periodically updated as more information becomes available. For the most current information, check with the federal agency or organization that provides it. Some regulations and recommendations for nickel include the following. The EPA states that long-term exposure to 0.02 mg nickel/kilogram (kg) of body weight/day in food or drinking water is safe for humans. This value is for nickel compounds that dissolve easily in water. Nickel levels in workplace air are regulated by OSHA, which has set an occupational exposure limit of 1 mg nickel/m^3 for an 8-hour workday, 40-hour workweek. The recommended exposure limit set by NIOSH is 0.015 mg nickel/m^3 for nickel metal and other compounds. See Chapter 7 for more information.

1.8 WHERE CAN I GET MORE INFORMATION?

If you have any more questions or concerns, please contact your community or state health or environmental quality department or:

Agency for Toxic Substances and Disease Registry
Division of Toxicology
1600 Clifton Road NE, Mailstop E-29
Atlanta, Georgia 30333

1. PUBLIC HEALTH STATEMENT

*Information line and technical assistance

Phone: (404) 639-6000
Fax: (404) 639-6315 or 6324

ATSDR can also tell you the location of occupational and environmental health clinics. These clinics specialize in recognizing, evaluating, and treating illnesses resulting from exposure to hazardous substances.

*To order toxicological profiles, contact:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Phone (800) 553-6847 or (703) 487-4650